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Multicolor photometry of SU UMa and U Gem during quiescence, outburst and superoutburst.

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Abstract. The results of time-resolved observations of SU UMa and U Gem obtained over two-years are presented. Both stars are prototypes of different classes of dwarf novae. We studied brightness variations on different time scales: orbital, QPO and flickering. The multicolor *BVRI* photometry allows to distinguish the geometrical and physical sources of these variations.

Introduction

The aim of our work is to separate geometrical phenomena (e.g. eclipses, disk precession) from physical phenomena which occur in two prototype dwarf novae: SU UMa and U Gem. In particular, we study the influence of such phenomena on flickering variability observed in our multicolor light curves of these systems. The flashes are observed with the mean spacing 15 days for the normal outbursts and about 260 days for superoutbursts in the case of SU UMa. Only normal outburst with mean spacing about 100 days are observed in the case of U Gem. Our observations were collected during three distinct phases of activity: quiescence, outburst and superoutburst. For SU UMa, these are most probably the first observations obtained in all phases of activity using one 4-band photometric system.

Observations

We performed the observations from Jan 2006 to Feb 2008 using a 60 cm Cassegrain telescope at the Astronomical Observatory of the Nicolaus Copernicus University in Piwnice, near Torun, Poland. We observed in *B*, *V*, *R_c* and *I_c* bands and in a white light mode. In the current paper we do not present *V* and *R_c* light curves. Exposure times for the SU UMa observations were 40 sec and 30 sec in *B* and *V* bands, respectively, and 20-25 sec in *R_c* and *I_c* bands. The resultant time resolution was approximately 95 sec. The exposure times used for the U Gem observations were 20-60 sec in *B*, 20-40 sec in *V*, 10-20 sec in *R_c* and 5-15 sec in *I_c*, with time resolution of 135 sec. For the observations collected in the white light mode for both stars, the exposure time was set to 5 sec which resulted in a time resolution of 8 sec. The level of accuracy of our measurements was 0.01 mag. In order to phase our data, we adopted the following ephemeris from the literature:

SU UMa: $HJD_{ic} = 2446143.6627 + 0.076351 \times E_{orb}$ (Thorstensen 1986)

U Gem: $HJD_{min} = 2437638.8270 + 0.17690619 \times E_{orb}$ (Krzemiński 1965, Marsh 1990).

Where HJD_{ic} concerns the spectroscopic inferior conjunction of emission lines source for SU UMa, and HJD_{min} is the mideclipse moment for U Gem. Light curves of SU UMa obtained without filter and in B and I_c bands as well as $B - I_c$ colour indices are shown in Figure 1. The corresponding light and colour curves of U Gem are presented in Figure 2. We do not show our observations during outburst of U Gem because they do not cover the whole orbital period.

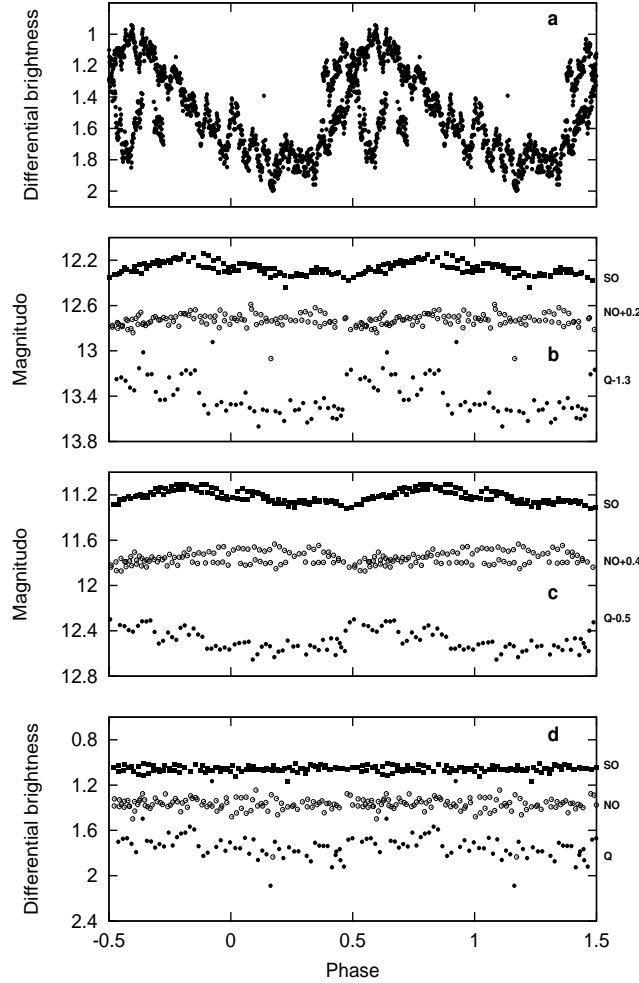


Figure 1. Light curves of SU UMa: (a) unfiltered at quiescence (Feb. 15, 2008); (b) B light at quiescence (May 9, 2006), outburst (Sep. 12, 2006) and superoutburst (Sep. 25, 2006); (c) the same as previous panel but in I_c light; (d) the $B - I_c$ colour indices obtained with the data from two upper panels: quiescence (Q), outburst (NO), superoutburst (SO).

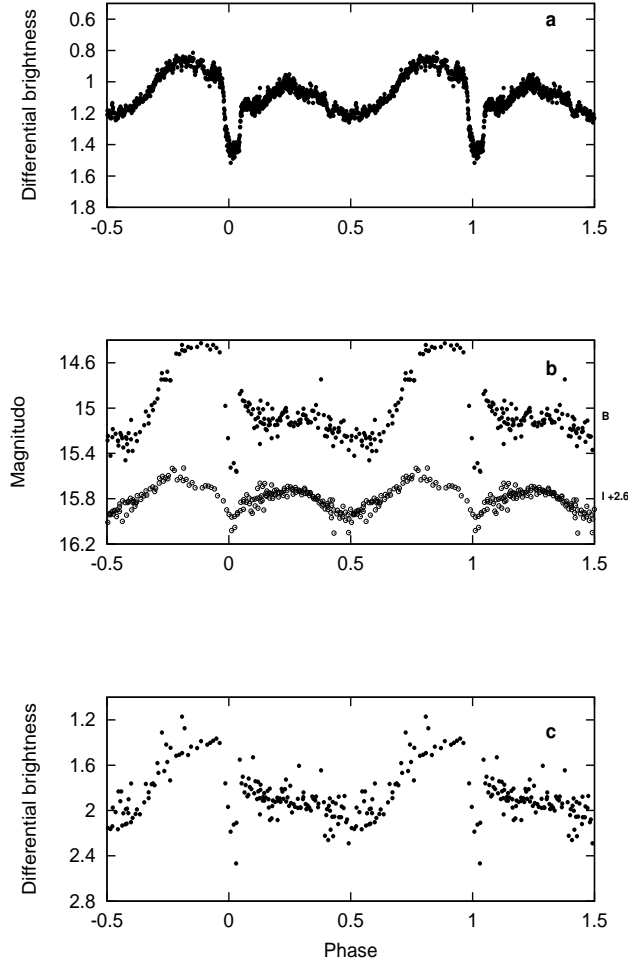


Figure 2. Light curves of *U Gem* at quiescence: (a) unfiltered (28.12.2007); (b) *B* and *I_c* filters (Jan. 7, Mar. 22, 23, May 9, 10, 14, 2006); (c) the $B - I_c$ colour indices obtained with the data from previous pannel.

Discussion

We noticed fast flickering and orbital changes of the brightness during the quiescence phase in *SU UMa* and *U Gem* systems (Figure 1 and 2). Especially both unfiltered light curves show almost identical pattern of these variations during whole orbital period, if we neglect the eclipses in *U Gem*. The higher amplitude of such variations in the case of *SU UMa* is a result of the dominant influence of hot spot over the accretion disk and the other components of the system on the light curve. Moreover, the unfiltered observations during the quiescence and the *I_c* observations during the outburst phase, indicate an additional slow pattern of changes on timescales compatible with the orbital period.

During the superoutburst phase, characteristic superhumps are apparent in the light curves of SU UMa. $B - I_c$ color index is constant for both superoutburst and outburst phases, which suggests that the changes of the system geometry are responsible for the observed superhumps. It was discussed by Udalski (1990) that the superhumps are the result of disk precession. The maxima of superhumps during superoutburst occur in different phases than orbital maxima during quiescence. The precession in the orbital motion direction causes their period of changes to be longer than orbital period.

Highly time resolved observations in a non-filter mode in the quiescence show flickering variability on timescales of minutes and amplitudes of 0.05-0.1 mag in U Gem (Figure 2a) and even 0.7 mag in SU UMa (Figure 1a). The flickering amplitude in both stars increases toward the shorter wavelengths during the quiescence and almost disappear during the outburst and the superoutburst phases in SU UMa. The maximum amplitude corresponds to the best visibility of the hot spot (face-on) near phase 0.6. On the other hand, in the case of U Gem flickering is well visible not only when the hot spot is well seen (Figure 2a). The flickering is most pronounced near phase 0.4 when the hot spot does not face the observer. Thus, the influence of intrinsic accretion disk instabilities seem to be a very important source of flickering in U Gem.

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References

- Krzemiński W., 1965, *ApJ*, **142**, 1051-1067
 Marsh T.R., Keith Horne 1990, *AJ*, **364**, 637-646
 Thorstensen J. R., Wade R. A., Oke J. B. 1986, *ApJ*, **309**, 721-731
 Udalski A., 1990, *AJ*, **100**, 26-232